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ABSTRACT

Previous research in the field of student learning in higher education has mostly focused on conceptual issues of students at the individual concept or task level. There has been little research of students' conceptions of whole subjects, and virtually no previous research of students' feelings of their conceptual experiences. This paper aims to analyze students' experiences of studying a whole subject and their feelings associated with those experiences. The sample consisted of two interviews with twenty-four first year university physics students. In analyzing students' experiences, two related methodological approaches were used. The first phase of analysis adopted a phenomenographic approach, resulting in the development of categories of description of the variation within students' meaning of understanding. The second phase of the analysis adopted a metaphoric approach, where the variation within students' feelings associated with their meanings of understanding were analyzed. In this paper, the authors present the set of categories of description they developed to describe the variation in the way students conceive of understanding. In presenting these categories of description, the discussion will point towards the (Contains 24 references and 3 tables.) (Author/ASK)

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Students' Experiences of Understanding University Physics

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Abstract

Previous research in the field of student learning in higher education has mostly focused on conceptual issues of students at the individual concept or task level. There has been little research of students' conceptions of whole subjects, and virtually no previous research of students' feelings of their conceptual experiences. This present research aims to analyse students' experiences of studying a whole subject and their feelings associated with those experiences. The sample consisted of two interviews with twenty-four first year university physics students. In analysing students' experiences, two related methodological approaches were used. The first phase of analysis adopted a Phenomenographic approach, resulting in the development of categories of description of the variation within students' meaning of understanding. The second phase of the analysis adopted a metaphoric approach, where the variation within students' feelings associated with their meanings of understanding were analysed. In this paper, we will present the set of categories of description we developed to describe the variation in the way students conceive of understanding. In presenting these categories of description, the discussion will point towards the beginnings of the metaphoric phase of analysis. In analysing the data using both methodologies, we aim to gain insight in to the nature of individual experience.

Introduction

Previous research from the student learning in higher education perspective, has highlighted the relationship between students' adopted approaches to study and their perceptions of the learning context. Other research has looked at students' understandings of a particular phenomenon and how this relates to students' approaches to study and their perceptions of learning. The focus of this study is the relationship between students' adopted approaches to, perceptions of and understandings of their studies in a particular topic in university physics. The combination of these three aspects, gains insight in to students' experiences of studying the subject matter in a particular context.

The student learning in higher education literature, has focused on students' conceptions of key concepts or tasks. Most of this research has been on the cognitive aspects of the students' experiences of the key concepts. There has been little research on the effective aspects of the students' experiences of key concepts, and even less research on the cognitive and effective aspects of the students' experiences at the whole topic level. The point of departure of this study is the focus on the whole topic rather than individual concepts within that topic. Specifically, the focus is both the cognitive and effective aspects of students' experiences of learning a whole topic in a first year university science course.

Students' adopted approaches to studying has been the focus of a substantial amount of research in student learning in higher education. The research identifies students' adopting both surface and deep approaches (Biggs, 1987a, b; Ramsden, 1992; Marton, Hounsell & Entwistle, 1997). The relation between students' adopted approaches to studying and their perceptions of the learning environment is furthered researched in other papers. These papers identify a deep approach to be associated with deep perceptions, such as, good teaching, clear goals, independence in learning, and appropriate assessment and workload (Ramsden, 1992; Trigwell & Prosser, 1991b; Prosser, Hazel, Trigwell & Lyons, 1996).

Students' conceptions of learning have been documented in recent research (Saljo, 1979; Marton, Dall'Alba & Beaty, 1993; Crawford, Gordon, Nicholas & Prosser, 1994). The research found six conceptions of learning, ranging from an increase in knowledge to an interpretive process aimed at understanding reality. The conceptions of learning, held by the students, influence their present learning situation. As well as the influence of students' prior conceptions of learning, recent research has found students' prior experiences of learning influence their current experiences of learning (Entwistle & Ramsden, 1983; Prosser & Millar, 1989).

The variation in student learning outcomes has been the focus of research in the past and continues to be a focus today (Johansson, Marton & Svensson, 1985; Prosser & Millar, 1989). The studies show limited conceptions of phenomena are held by many of the students. The relation between student learning outcomes and their adopted approaches to studying the subject matter, has also been the focus of recent research (Tang, 1998; Crawford, Gordon, Nicholas & Prosser, 1994; Trigwell & Prosser, 1991a). These studies show a student adopting a deep approach will tend to have a high result in the assessment tasks, while a student adopting a surface approach will tend to have a low result.

The Phenomenographic perspective of student learning is a relational or constitutional perspective, the focus of which is on learning being a relational phenomenon, relating the student to that which they are studying. The name constitutional comes about because knowledge is seen to be constituted in the relation between subject and object. The importance of this statement is the implication that research conducted from this perspective must take in to consideration both the phenomenon in question and the learner. A relational perspective does not focus on the phenomenon, but how that phenomenon is experienced (Trigwell & Prosser, 1991b; Entwistle & Tait, 1995; Marton, 1988).

In this research study, the focus was on the development of sets of categories of description of certain phenomena. Phenomenography is contextual, therefore, the phenomena in question is in the context of a course in mechanics. The results, in this case, the sets of categories of description developed, exist only in the data, and only for that specific context. The act of learning can not be separated from the object of study. To have an experience, you must have an experience of something. Learning is constituted in the equal relation between situation and individual.

When analysing student responses, the focus is on what is at the front of their awareness, rather than whether the students' responses are correct. There are unlimited ways of conceptualising a phenomenon, but there are a limited number of ways key concepts of the phenomenon are conceptualised. In other words, variation in meaning is infinite, however, the variation in the key aspects of meaning is limited. In some cases, the set of categories of description are hierarchical in nature. Although categories are content-dependent, there is an overall general structure to the categories (Dahlgren, 1984; Lyons & Prosser, 1997).

Beyond Phenomenography, it is the transcript that is being classified, not the individual (this is not a psychological study). Phenomenography is the 'what' and the 'how' of learning, not the 'why'. In Phenomenography, variation among students is the focus, not individuals. The sets of categories of description developed represent the variation within a group of students. Therefore, no themes or further analysis for the individual, using a Phenomenographic analysis, is possible.

In recent studies, students' feelings associated with deep understanding were described. The study identified seven associated feelings: satisfaction; meaning and significance; coherence and connectedness; provisional wholeness; relative irreversibility; confidence about explaining; and flexibility in adapting and applying. Metaphor may serve to give us insights or ideas, and are an essential aspect of language in terms of transference of meaning (Entwistle & Entwistle, 1992; Entwistle, Marton & Entwistle, 1993; Entwistle & Marton, 1994).

The Metaphorical perspective of student learning focuses on the students' experiences of learning. Metaphors offer a different way of perceiving reality. They portray human communication as the transfer of thoughts and feelings. In other words, experience can be described metaphorically. The term metaphorical-theme is derived from

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the contextual use of metaphorical statements and represents what is at a student's focal awareness (Black, 1979; Boyd, 1979; Kuhn, 1979).

Metaphor cannot be reduced to a simile or be considered as a literal comparison between two objects because metaphor has an intuitive and emotive character. We do not always have a thought and then put it into metaphorical terms, rather the metaphor itself interacts with and helps to constitute the thought. Some metaphors enable us to see aspects of reality that the metaphor's production helps to constitute, a world seen from a certain perspective (Shibles, 1971).

The metaphorical perspective adopted in this research is the interaction view. Within this view, there is primary and secondary subjects. The primary subject refers to the what the students focus on, while the secondary subject refers to the framework in which the focus is a part. The secondary subject is a system rather than a thing. The metaphorical utterance works by projecting upon the primary subject a set of associated implications.

The experience of learning, focuses on aspects of learning in relation to students' awareness and experiences. The experience of learning is constituted in the relation between the students' approaches to studying, their perceptions of their learning context, their conceptions of phenomena, and their feelings associated with understanding phenomena. In analysing students' experiences, Phenomenographic and metaphorical analyses will be adopted. The former analysis addresses the variation within a group, while the latter, addresses the feelings of individuals.

In this paper, we describe an aspect of the results of a larger study aimed at describing students' experiences of learning in a first year university physics course in Newtonian mechanics. The paper focuses on some of the students' cognitive and effective aspects of their understanding of mechanics. The students' conceptions of understanding mechanics are represented in this paper as a set of categories of description, while the students' feelings associated with their understandings are represented as metaphorical-themes. The methodologies adopted in the larger study are described in the section below.

Methodology

In the larger study, which this paper is a part, two different, but related, methodological approaches were used to analyse the data. The first methodology, a Phenomenographic analysis, aims to document the key aspects of the variation within students conceptions of a particular phenomenon. The second methodology, a Metaphorical analysis, aims to document students' individual experiences of that phenomenon.

The sample used in the study consisted of two interviews with twenty-four first year university physics students, giving a total of forty-eight transcripts. The students were all enrolled in the same course in physics at the same university. The first interview, conducted in the first few weeks of first semester, focused on students' experiences of their most recent study of mechanics. (For most students, the focus of the interview was the study of mechanics in the previous year as part of their year twelve studies in physics.) The second interview, conducted in the first few weeks of second semester, focused on students' experiences of studying mechanics in the first semester of their university studies in physics.

The aim of the Phenomenographic approach to the data, was to develop sets of categories of description of students' conceptions of phenomena relating to their studies in mechanics. The categories were found within the transcripts, by which we mean, there were no pre-determined categories taken to the data. The set of categories form an inclusive hierarchy, the most developed category being inclusive of the other less developed categories.

In the larger study, sets of categories of description were developed for students': (1) approaches to studying mechanics; (2) perceptions of their learning context while studying mechanics; (3) conceptions of the motion of a yoyo; (4) conceptions of mechanics; (5) conceptions of physics; and (6) conceptions of understanding mechanics. This paper, however, will only focus on the set of categories of description developed for students' conceptions of understanding mechanics. The set of categories of description developed and how these categories are structured are shown in Tables 1 and 2 respectively.

The aim of the Metaphorical approach to the data, was to develop metaphorical-themes representing students' feelings associated with understanding mechanics. Twelve interview transcripts, six student interview sets, of the original forty-eight were used. The metaphorical-themes were found by analysing students' utterances relating to understanding, learning, knowledge, teaching, and physics. For each transcript, a dominant metaphorical-theme(s) was identified. The dominant metaphorical-theme(s) for each transcript and the corresponding category of description of understanding mechanics are shown in Table 3.

Part of a student's experiences of their first semester of university physics, can be documented through the set of categories of description of the student's conception of understanding mechanics and the dominant metaphorical-theme of their feelings associated with their understanding of mechanics. This paper will focus on one student's pre and post interviews. The category of description of their conception of understanding mechanics (represented by the student's responses) is discussed in relation to their dominant metaphorical-theme identified through both of their interviews. This vignette in shown in the discussion section.

Results

Categories of description

The set of categories of description for students' conceptions of understanding within a mechanics context are summarised below (Table 1). The set of categories of description were developed from the twenty four pre and post interview transcripts. Table 1 exemplifies the hierarchical relationship between the categories. Conception A is the least inclusive category, while conception E is the most inclusive category.

Table 1 Categories of Description for Conceptions of Understanding

Cat.	Description	Awareness	Explanation
A	no physical description	focus is on the undifferentiated whole	understanding is seen as given, no effort required
B	understand when you can solve problems	focus is on the undifferentiated whole in relation to what the student perceives	understanding is when students know they can solve given problems
C	understand when you can relate to real life situations	focus is on differentiated objects in relation to what the student perceives	understanding is when you can apply what you know to real life objects
D	understand when you can explain it to others or yourself	focus is on differentiated objects in relation to what the student experiences	understanding is when you feel confident with explanations of objects
E	understand when you consolidate your knowledge	focus is on integrated phenomenon in relation to what the student experiences	understanding is when you feel you know the phenomenon deeply

The least complete category of description, category A, is exemplified in aspects of the pre interview with student response number ten. In their response, student number ten focused on an undifferentiated whole. The student response described understanding as given, in that no effort on part of the learner is required. The student justifies their response by likening understanding to the accepted, logical, commonly held perception. The following quote from student response number ten exemplifies this. "Well, when the basic concept makes sense and is in line with what other people perceive it as. And logically, when I apply it, it makes sense, words in general I guess. It just clicks in your mind, it makes sense", (p. 4).

Aspects of the post interview for student response number eighteen exemplifies conceptions of understanding category B. In their response, student number eighteen focused on an undifferentiated whole in relation to what the student perceived. According to their response, understanding occurs when students know they can solve problems they are given. The student refers to possessing confidence about and the ease associated with problem solving. As student response number eighteen states: "... be able to be confident in answering a wide range of questions. When you can easily, without too much effort, be able to answer some questions", (p. 6).

Conceptions of understanding category C is exemplified in aspects of the post interview with student response number twenty-three. In their response, student number twenty-three focused on differentiated objects in relation to what the student perceived. According to their response, understanding occurs when students can apply what they know to real life situations or phenomena, or be able to visualise the situation or phenomena. The student refers to the experience of the phenomena as helping them to understand it, as demonstrated in the following quote: "I can visualise it and you've experienced it, I think so. If you're going in a car you know that getting faster over time, you can understand what that is easily, so. That's just another way of explaining acceleration", (p. 11).

Conceptions of understanding category D is exemplified in aspects of the post interview with student response number two. In their response, student number two focused on differentiated objects in relation to what the student experienced. According to their response, understanding has occurred when you feel confident with your own explanations of phenomenon. This confidence may be reached either by explaining phenomenon to themselves or to others. "If you can explain it back to someone, ... if you can explain it another way as well, so you not only have your one set explanation but if someone says what are you on about, like be able to have the same information but rearrange it, so it's explained in a different way", (p. 8).

The most complete category of description of conceptions of understanding, category E, is exemplified in aspects of the post interview with student response number fifteen. In their response, student number fifteen focused on integrated phenomenon in relation to what the student experienced. According to their response, understanding has occurred when you feel you know the phenomenon deeply. Due to this deep understanding of phenomenon, the student is able to consolidate their knowledge. "It's more of a gut feeling when you think, 'yeah, this is right', or else with some things you can go out and prove it. I've got a fair idea that I chuck a ball at that wall it'll bounce back, and I can prove that", (p. 6).

The focal awareness students' hold for the set of categories of description for their conceptions of understanding in a mechanics context is shown in Table 2. The 'what' and 'how' of learning have been included in the figure in terms of the students' focal awareness. In this case, 'what' has been referred to is either given, perceived, or experienced (in relation to). The 'how' that 'what' has been structured is in terms of undifferentiated whole, differentiated objects, or integrated phenomenon (focus). The Figure shows three structural levels, category A and B, category C and D, and category E. The student responses become more sophisticated as the structural level increases.

Table 2 Focal Awareness for Categories of Description Understanding

Focus	In relation to		
	Given	Perceived	Experienced
Undifferentiated Whole	A	B	
Differentiated Objects		C	D
Integrated Phenomenon			E

Metaphorical-themes

The four metaphorical-themes developed from the selected group of twelve interview transcripts, were: ideas are actions; ideas are locations; ideas are objects; and ideas are perceptions. An individual's dominant metaphorical-theme developed from their transcript, is the result of a quantitative analysis of the metaphors corresponding to each metaphorical-theme. This is to avoid laying importance on some metaphors that are carried over from one social setting to another and, therefore, may not be indicative of the current situation.

The dominant metaphorical-theme(s) for each transcript, and the corresponding category of description for the student's conception of understanding mechanics is shown in Table 3. For student identified in the table as number 5, the dominant metaphorical theme for their pre interview was *ideas are objects*. Their responses in the pre interview, indicated a conception of understanding mechanics category B. For the post interview, the dominant metaphorical-theme was *ideas are perceptions* and their conception of understanding a category C. The pre and post interviews with this student will be discussed further in the discussion section of this paper.

Table 3 Dominant Metaphorical-theme(s) and Category of Description of Understanding

Cat	Ideas are			
	Actions	Locations	Objects	Perceptions
A			1 post	
B	1 pre		1 pre, 2 pre, 5 pre	
C	4 post	2 post	2 post	2 post, 4 post, 5 post
D	6 pre		3 pre, 6 pre	3 pre, 6 pre
E			3 post, 6 post	3 post, 4 pre, 6 post

Discussion

Vignettes

This section focuses on one student's dominant metaphorical-theme relating to understanding and their relation between the category of description developed for that student's conceptions of understanding mechanics. The student is one of the twenty four students interviewed in the study. The student was interviewed twice after a course in mechanics, first in year twelve physics in the previous year, and second in their first semester of university physics. The student's responses were categorised differently for their conceptions of understanding and they also developed two distinct dominant metaphorical-themes for each course.

For each of the student's interviews, one dominant metaphorical-theme was identified. In the pre interview, the student verbalised fifteen utterances relating to the metaphorical-theme *ideas are objects* . The student also had utterances relating to the other three metaphorical-themes; however, due to the low number of utterances relating to them the three themes were recessive. For their post interview, the student verbalised seventeen utterances for the metaphorical-theme *ideas are perceptions* ., and a lesser amount for the three other metaphorical-themes.

In their pre interview, the student describes understanding as knowing that you can solve given problems. This relates to the metaphor of learning as receiving objects. The knowledge required to solve questions is intertwined throughout the problems. In respect to the metaphorical-theme, the student describes understanding as the grasping of an object. They also refer to understanding as the act of remembering the objects they have received. "Understanding motion would be looking at the forces and energies required and involved in the movement of an object ... When I can look at an exam paper or something and know I'll have no trouble doing the questions on the exam paper", (p. 5).

In their post interview, the student describes understanding as when you can relate the knowledge learnt to real life situations. This relates to the metaphor of learning as discussing perceptions. The knowledge required to visualise situations is intuitive and inclusive in that there is a general build up of ideas. In respect to the metaphorical-theme, the student describes understanding as seeing the situation. "I suppose if I see a question and know off hand straight what to do ... Except normally when you understand something there's always something you still don't understand", (p.7).

Conclusions

A set of categories of description were developed for students' conceptions of understanding mechanics. Five categories were found, ranging from the least complete category A to the most complete category E. The categories are hierarchical and inclusive, in that category E is inclusive of the lesser categories A to D. The set of categories of description represent the key aspects of the variation within the group, not the individual.

A set of four metaphorical-themes were developed for the students' feelings associated with their conceptions of understanding mechanics. The students utterances are contextual and were classified in to metaphors which include the associated implications of the utterances. The metaphors were then summarised as metaphorical-themes which represent what is at the students' focal awareness. Dominant metaphorical-themes were then classified as representing the actual situation being investigated.

The vignette of one student's interview transcripts shows the relationship between the student's category of description of understanding mechanics and the dominant metaphorical-theme associated with their understanding. The dominant metaphorical-theme was evident in the student's descriptions of understanding, thus representing an integrated awareness during the interviewing. The student developed their conception of understanding mechanics to a more complete category, and their dominant metaphorical-theme from external to internal aspects.

The aim of this research was to gain insight in to the nature of individual experience of learning in a first year university physics course. We have found a strong relationship between students' conceptions of understanding and the language they use to describe their associated feelings. By documenting students' conceptions of understanding and the dominant metaphorical-theme(s) relating to understanding, we have shown a more complete picture of students' experiences of learning.

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